Minot (C. S.) & Burgess (Ed.)

AUTHORS' EDITION.

REPORT

ON THE

ANATOMY OF ALETIA XYLINA,

BY

CHARLES SEDGWICK MINOT

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[Extracted from the Fourth Report of the U. S. Entomological Commission, being a report on the Cotton Worm, etc.]

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CHAPTER V.

ON THE ANATOMY OF ALETIA.

By Charles Sedgwick Minot and Edward Burgess.

[Plates VI–XI.]

The following chapter was prepared at the request of Professor Riley, to whose kindness we are indebted for the material upon which our observations have been made. Several untoward circumstances have contributed to interfere with the progress of the investigation. The work was begun by Dr. Minot, who was subsequently joined by Mr. Burgess, in the hope that our joint labors would prove more efficient. Nevertheless we find it necessary to leave various points undecided. This incompleteness is partly due to the unavoidable imperfection of preserved specimens,* and partly to the scanty light yet thrown on insect anatomy and physiology.

ANATOMY OF THE LARVA.

The external anatomy of the larva need not be again described in this chapter. There are only a few points to be noted in regard to the legs, the previous descriptions of which are somewhat incomplete. The true legs, Plate VI, Fig. 4, are conical, three-jointed, and provided with a terminal hook, Fig. 6, which is curved toward the median line of the body, and has at its base a thick swelling, usually described as a fleshy pad; the adjective fleshy is hardly appropriate, as the pad is covered by a well-developed, hard crust. There are two hairs on the first joint, the lower being much the slenderer. There are four hairs on the lower part of the second joint, two on the inner edge rather stout and curving, and one fine one just below them, and a long one in front. On the last joint again are four hairs, all near the terminal claw, namely, a small one in front, a thick, curving one on the side, another thick, curving one just above the pad of the claw, and immediately above this the fourth hair, which is shaped something like an Indian club, and is apparently somewhat flattened. The constancy of form and disposition of these hairs lead us to think that their arrangement must be of some importance, therefore we have given this detailed description.

*Some material preserved in a 5 per cent. solution of chloral-hydrate was found very useful. With this preservative, specimens should be opened in several places to allow the fluid to penetrate into the interior. Indeed this should be done with alcoholic specimens also.

The false feet or prolegs, Plate VI, Fig. 2, of which there are five pairs, the first pair considerably smaller than any of the others, as is well known, differ entirely from the true, anterior or permanent legs. They are thicker, cylindrical, and one-jointed; they have a few long hairs, and are armed with a row of a dozen and a half curved hooks. The hooks turn towards the median line of the body; they diminish in size from the center of the row towards each end. Each hook consists of a more cylindrical, large basal portion, which appears to be chiefly imbedded in the flesh of the foot, and a recurved hook proper, Plate I, Fig. 3, which has a very thick cuticula. There is also a pigmented pad, which lies over the base of each hook on the inside of the foot. We could find no certain evidence of a second row of hooks such as have been described in many caterpillars, though possibly there are very small claws on the pigmented pads above described.

The markings, colored stripes and dots, that decorate the larva, are produced by various means, partly by deposits in the matrix of the crust (epidermal cells), partly by colors of the crust itself. The dark-brown color belongs to the crust, and is peculiarly distributed in a manner that has not, so far as we are aware, been described hitherto. Upon the outside of the crust is a very thin but distinct layer, which in certain parts rises up into a great number of minute, pointed spines that look like so many dots in a surface view, Plate VI, Fig. 8. Each spine is pigmented diffusely, and together they produce the brown markings. The spines are clustered in little groups, one group over each underlying matrix, or epidermal cell.

The stigmata of the larvæ are small vertical fissures on the sides of the segments. The first, fourth, and subsequent segments have each a pair, making nine in all; there are none on the second and third rings. Viewed from the surface they are seen to be provided with an anterior lip, which is simple, and a posterior lip, which bears a projecting lever. Both these lie quite deep down and serve to close the trachea. Above each lip are several rows of hairs that are short, branching, and spine-like. The stigmata form the subject of a recent excellent memoir by Oskar Kraucher,* a pupil of Rudolph Leuckart, the distinguished professor of zoology at Leipzig. On pages 543–546 of this essay the stigmata of caterpillars are fully described. According to Kraucher, the lever-bearing, or posterior, lip is more developed than the anterior. (The former was named by Landois the *Verschlussbügel*, the latter the *Verschlussband;* but these names are not specially appropriate, and we prefer to use anterior and posterior lip instead.) The lever arises from the upper end of the posterior lip. In most of the diurnal lepidoptera it is a simple chitinous rod, but in some of the Bombycidæ it is more complicated. Attached to the lever is a double muscle; one part, running to the lower end of the lever-bearing lip, serves to approximate

* Oskar Kraucher. Der Bau der Stigmen bei den Insekten. Zeitschr. f. wiss. Zoologie, XXXV, 1881, pp. 505–575, Taf. XXVIII–XXIX.

the two lips, and so close the opening between them; the other part is attached to the neighboring epidermis, and serves to open the lips. Only this latter division of the muscle, which is considerably the larger, was described by Landois.*

The internal anatomy of the larva agrees closely with the lepidopterous type, as established by previous observers. In the head, Plate VII, Fig. 1, the digestive canal begins with the large mouth *m*, lined by a dark, firm cuticula and passing over into the narrow muscular œsophagus, *Oe.* Behind the mouth is a projecting pointed process at the tip of which opens the salivary duct. Above and in front of the mouth there is a distinct mass of tissue, of a fibrous, areolar character, spreading out fan-like from the upper wall of the œsophagus and attached in front to the lower part of the clypeus and to an endocranial process. In this mass of tissue lies the small frontal ganglion. Above the œsophagus is the brain, *br;* below it the subœsophageal ganglion *S*, connected by a short commissure with the first ganglion of the ventral chain.

The rest of the internal anatomy is illustrated by Fig. 1, Plate VI. In the first (thoracic) segment the œsophagus expands into the enormous stomach *St.*, which runs through eight segments, and is by far the largest and most conspicuous organ of the body. From in front backwards it gradually widens, but posteriorly it is rounded off. Into the hinder end open the malpighian or urinary vessels *m. v.*, six in number, three on each side uniting together and opening by a short duct. The salivary glands lie upon each side of the stomach, having long ducts which reach through the anterior three segments of the body. The gland proper, *Sal.*, is an elongated tube, gradually diminishing in diameter towards its posterior end or tip; its course is curious; it runs some distance straight backwards, then makes a sharp angle over the second proleg and runs forwards and upwards, then another sharp crook over the first proleg and it continues backwards again and slightly upwards. Behind the stomach the intestinal canal consists of four parts: first a short, constricted connecting piece; second a dilated, oval division, *In.;* third the short rectum *R.;* fourth the short anal tube. The dorsal vessel or heart, *d. v.*, is a long tube placed above the digestive canal, and extending through nearly the entire length of the body. The ventral chain of ganglia numbers eleven distinct knots, the last being however evidently double. The first ventral ganglion is the subœsop..ageal; the second lies so near it as to be almost united with it. The others lie at regular intervals, until the tenth, which is pushed a little forward of its original position over the fourth proleg. The eleventh double ganglion lies close to the tenth and gives off a large number of nerves, most of which run backwards.

The large stomach alone represents the entodermic canal, and presents

* Landois. Zeit. wiss. Zoologie, 1867.

the same essential peculiarities of minute structure as were described by Minot* in the orthoptera. The lining epithelium is thrown up into folds so as to form imperfectly differentiated glandular follicles. If the epithelium be brushed off, the characteristic arrangement of the muscular fibers can be seen, Plate VI, Fig. 7. There is an internal coat, composed of a great number of pale fibers running transversely around the stomach and more or less parallel to one another. Outside are the longitudinal striped muscles, which are distributed in single bundles, *l l*, and do not form a continuous layer. Each bundle is composed of a number of fibers and pursues its own course; the bundles are not parallel, but sometimes two bundles unite, or are connected by a third; their general trend is longitudinal. Finally it must be mentioned that numerous tracheal branches penetrate the muscular layers, and ramify through both them and the connective tissue.

EXTERNAL ANATOMY OF THE IMAGO.

To prepare the external skeleton for examination the following method is satisfactory and convenient. The whole insect, either in the fresh state or after preservation in alcohol, is placed in a test tube with a solution of caustic potash and carefully boiled over a flame for a couple of minutes. The specimen is then thoroughly washed with water, to which a little acetic acid or vinegar is added to neutralize the alkali. The specimen while in this state may be brushed with a camel's-hair pencil, and most of the scales removed. It is best to put it next, for twenty-four hours, in strong alcohol and to then complete the brushing upon the hardened object. With a little care and patience all the hairs and scales can be removed without injuring the crust.

A view of the exoskeleton of the female is given on Plate VIII, Fig. 1. We shall follow Mr. Burgess' memoir upon the Milkweed Butterfly,† as to the homologies and nomenclature of the parts. The head is more triangular in outline, when seen from the side, than in Danais, and the eyes, *E*, are relatively smaller. The palpi and maxillæ are very similar to those of the butterfly. The antennæ, *a*, are thicker and the enlargement of the two basal joints is quite marked. The thorax is large and compact. The first segment (I) is small, the second (II) by far the largest of the three. The prothorax is connected with the head by a narrow neck, which is perhaps really the anterior portion of the first thoracic segment. This point is better shown in a view of the underside, Plate IX, Fig. 1. The front legs are there removed; the insertion of coxæ into the thorax is shown at l^1; just in front of this insertion is a thickened ring of hard crust; farther forwards the integument is membranous, and the prothorax proper becomes directly continuous with

* Minot, C. S. Histology of the locust (*Caloptenus*): and the cricket (*Anabrus*): Chapter X, in Second Report of the United States Entomological Commission. 1880. Pp. 183–224. Plates II–VIII.

† Burgess, Edward. Contributions to the Anatomy of the Milkweed Butterfly (*Danais archippus*, Fabr.). *Anniv. Mem. Boston Soc. Nat. Hist.*, 1881.

the neck. So, too, a median section shows that the neck and prothorax are really one, Plate VIII, Fig. 2. Two pendulous lobes s^1, Fig. 1, Plate VIII, project from the upper side of the prothorax, which appear to belong to the scutum, but their real homologies are not yet determined with certainty. They are constricted around their bases, so as to be quite movable. Upon the sides, just behind and below them, lies the first spiracle, sp^1. Below the spiracle are two pieces of elongated shape, running down to the insertion of the coxæ; the anterior piece, eps^1, is the episternum, and meets its fellow on the ventral side, forming a median suture between the two coxal articulations, Plate IX, Fig. 1; the posterior is the homologue of the epimeron of the segments.

The mesothorax, Plate VIII, Fig. 1, II, is the largest segment of the body. It is longest on the upper side. The principal dorsal piece is the big scutum, s^2, below the lateral edge of which springs the front wing, w^1. Over the base of the wing runs back the large patagium, *pt*, which is very much developed; its only connection with the body is in front, where it bends over and, as it were, hooks around the front edge of the wing. The scutellum, sm^2, is also prominent and extends for some distance over the metathorax. The episternum, eps^2, is an oblong piece which runs backward, beginning just underneath the front end of the patagium, and is joined behind to the epimeron, epm^2. It is united below with a double piece, *st*, which extends downwards and backwards to the coxæ, cx^2. This piece was determined by Dr. Packard, in *Attacus*, as the sternum, and his nomenclature was followed by Burgess in his article on Danais. From our study of the Cotton Moth, it seems doubtful whether this interpretation can be sustained. The piece is double on each side, as can be especially well seen in a ventral view, Plate IX, Fig. 1. The same aspect also shows that the two pieces do not meet in the median line, but are separated by a clear triangular space, behind which lies a pair (*a*, *a*) of pieces which separate the coxæ and meet one another in the median ventral line. These are perhaps the real sternal pieces. In any case it is evident that further and extended study is necessary to elucidate the real morphology of these numerous components of the thoracic skeleton. The epimeron, epm^2 (Plate VIII, Fig. 1), is quite large and complicated. It consists of a hard V-shaped piece, between the two legs of which is a large, triangular membranous area. The anterior leg of the V is much the broader, and joins above to the episternum, and in front to the part marked *st*, which Packard has held for the sternum. The membranous portion between the legs presents an inconspicuous structure, which is perhaps a spiracle, although this could not be certainly established. The coxal joint, cx^2, tapers rapidly; examined from the outer surface it appears to consist of two pieces; the anterior piece has been called the *coxa*, the posterior the trochantine by some authors.

The metathorax (III) is particularly puzzling on account of its very complex structure, due at least in part to the development of numerous

air-chambers in the interior, accompanied by manifold ingrowths of the outer crust to serve as partitions between the adjacent air-chambers. As the ingrowths are connected with divisions of the exoskeleton, this last becomes very complicated, especially in the posterior lateral region below the wing and above the leg. The scutum, s^3, is well marked; immediately below it arises the hind wing, w^2. The piece which Burgess determined as the scutellum in Danais we have not found in Aletia; but what in the butterfly appears merely as the tip of the scutum is distinctly differentiated in the moth and is very probably the true scutellum; in this case the part so named in Danais would have to be considered as the post-scutellum. On the front edge of the segment, between the front edge of the wing and the coxal joint, is a single piece, eps^3, which seems to correspond to the two pieces, eps^2 and st^2, of the mesothorax, fused into one. In the posterior part, epm^3, there are a variety of structures, of which the most important are two, marked *A* and *B*. The former is a little quadrangular flap, which hangs down from just below the posterior edge of the hind wings. The latter, *B*, is a deep-lying, oval, pellucid membrane, which we think is probably homologous with the tympanal membrane of grasshoppers. The relation of these parts is better shown in the enlarged figure, Plate XI, Fig. 3, in which the oval membrane, *B*, and the flap, *A*, are both very distinctly drawn. We have not succeeded in observing any spiracle on this segment. The boundary between the metathorax and the abdomen is not clearly marked externally. The coxal joint, cx^3, is similar to that of the second leg.

A. H. Swinton has published a paper on the organ of hearing in lepidoptera,* in which he refers to the oval disk, which we have interpreted as a tympanum. According to Swinton, a nerve passes from the third thoracic ganglion obliquely across and round the elevator muscle of the hind wing to the supposed tympanum, where it is connected with a structure (Swinton's "membranous vesicle") which is apparently identical with the structure in like position in the grasshoppers, which latter was likewise originally described as a vesicle, but is now known to be really a cluster of rod-bearing, terminal organs, such as are now known to be the essential constituents of tympanal organs. For a general account of these apparatus see the résumé by C. S. Minot.† It is probable that the part we have described in moths is a real tympanum, and entirely homologous with that of Acridians, but the matter must remain uncertain until the terminal rods have been actually found.

The abdomen consists of nine segments, numbered 1–9, the last two not showing in the figure, being retracted into the seventh segment. The first is smaller than the second and succeeding segments, and, therefore, appears as a sort of thick stalk uniting the abdomen with

* Swinton, A. H. On an Organ of Hearing in Insects, with special reference to the Lepidoptera. Entomologist's Monthly Mag., XIV (1877), 121–126.

† Minot, C. S. Comparative Morphology of the Ear. Fourth Article. American Journ. Otology, IV (1882), 89–168.

the thorax. Each of the segments consists of a dorsal, two lateral (one on each side) and a ventral piece. The side piece or membrane of the first seven segments bears a spiracle. The first segment, in its transverse diameter, is nearly as broad as the thorax, but its dorso-ventral diameter is barely half as great. In front it bends over and inwards, especially at the sides, so that here (see Plate XI, Fig. 3) the crust, where it joins the thorax, faces towards the head. It is here that the spiracle (*sp*) is placed, so that in a side view of the abdomen we see the edges of the spiracle, and not its opening, as in the other segments; the spiracle looks forwards.

The structure of the spiracles is interesting. They are all essentially alike. Plate XI, Fig. 1, represents that of the second abdominal segment. The spiracle is a vertical fissure with two lips, of which the anterior is connected with a long tendon, to which are attached the muscles which move the lips. Outside the lips is a row of stiff hairs, or spines, which, standing out from the borders of the fissure, reach towards its center, so that those of the opposite sides nearly meet in the middle. Fig. 2 of the same plate gives a more magnified representation of a single spine. It rises from a pore-canal (or tube running through the cuticula), makes a bend at the start, and then runs out nearly straight, a thick stem, from the outer half of which arise a number of oblique prickles or thorns irregularly placed. The shaft consists of a hard sheath and a core or pulp. The hairs on the front edge are a little shorter than those on the posterior. At the top and bottom of the fissure the hairs become very small. The purpose of these spines is undoubtedly protective; they serve to prevent the entrance of foreign bodies, like the similar structures in the spiracles of the caterpillar. In the adult there is a single row of long spines; in the larva several rows of short spines.

The legs offer little requiring special description. The tarsal joints are five on each leg. After removal of the scales they are seen to be armed with a double row of spines on their inner margin (Pl. IX, Fig. 2), except the last joint, which has only hairs. The spines are shortest on the upper part of each joint and increase towards the distal end, the lowest spine being the longest. The end of the last joint bears in front two long, curving hairs, and behind the two recurved hooks, between which is placed the soft hairy pad, or pulvillus, *p*. The other joints are distinguished by their gradual diminution in length, the first or upper being the longest and having also the largest number of spines, as well as the greatest intervals between the adjacent spines. The scales on the legs are peculiarly grouped, being inserted in little clusters of some 10 to 15. Each cluster is very compact and elongated, in the sense of the long axis of the limb.

The scales are flattened hairs, divided into a blade of variable shape and a short pedicel, by which they are attached to the skin. The blade consists of a central portion, homologous with the core of hairs, and

a cuticular membrane, consisting, of course, of an upper and lower lamina, united at their edges and continued on the pedicel. Burmeister gives it as his opinion that the scale is empty between the two laminæ; but we cannot accept his view, because in those scales we have examined there is always an internal pulp, which often contains coloring matters. The scales have longitudinal striæ, which are produced by folds of the *outer* surface or lamina, as is at once shown by a cross-section of a scale (Plate IX, Fig. 1A). The upper surface is more nearly flat. The lower surface is recurved on each side. The scales are thickest in the middle line and thin out towards the edges. All these features were likewise observed by Burgess in Danais, and it is probable that they are common to the majority of the lepidopterous scales. There has been much dispute concerning the nature of the striæ on the scales, and Burgess was the first to describe their real character. Certainly Burmeister is in error when he says: "Il n'est pas douteux que les stries bien visibles des écailles soient des filets élevés au côté interne de la lame supérieure, se prononçant au côté externe seulement comme stries finement imprimées."* In many species, especially of butterflies, there are transverse striæ, which are said by Burmeister to be confined to the inferior lamina. In conjunction with the longitudinal striæ, they divide the scales into little squares. There is great variety in the form of the scales, but the study of these variations has hitherto borne little fruit. R. Schneider has published a memoir† on the form and distribution of the scales over the body in Lepidoptera, treating the subject with considerable detail. More interesting is Burmeister's essay, which contains the best general account with which we are acquainted.

The scales are inserted into peculiarly-shaped oblique pore-canals (Plate XI, Fig. 5). They begin on the outer surface with a wide open funnel that leads into a bulb or spherical dilatation of the pore. From the deep-lying surface of the bulb runs inward a fine tube. Apparently the stalk of the scale fits into the outer funnel, and is attached to the bulb.

The distribution of the scale pores is characteristic; they lie in little groups, which tend to spread out in lines having the same general trend, but never strictly parallel with one another (Plate XI, Fig. 4). On the legs, as already mentioned, there is a similar grouping, though not identical with that shown in Fig. 4. On certain parts, as, for example, the patagia and the membranous portions of the thoracic crust, the pores are scattered more evenly, each by itself.

The best account of the structure of the maxillæ, or proboscis, of butterflies is that given by Burgess, and an examination of this organ in Aletia reveals the same essential structure as in the butterfly, so that we may dispense with a detailed account. Plate XI, Fig. 6, represents

* H. Burmeister. Description physique de la République Argentine. Tome cinquième. Lépidoptères. (Examen spécial des Écailles, pp. 21–28.) Buénos-Ayres, 1878.

† R. Schneider. Die Schuppen an den verschiedenen Flügel- und Körpertheilen der Lepidopteren. Zeitschr. f. d. gesammt. Nat.-Wiss. III (1878). pp. 1–59. Taf. I–III.

just the tip, to show its peculiar outline and the spine-like structures, which probably have a sensory function. They are present in all Lepidoptera, but under a great variety of forms; in Danais they are reduced to small warts, but in many other genera they are large and conspicuous; for details the reader may consult Darwin and Breitenbach.* The spines are evidently modified hairs, for they are each placed over a wide pore-canal of the cuticula, and are themselves pointed chitinous tubes, as shown in the figures (Plate XI, Figs. 6 and 8). The spines consist of two parts, a cylindrical basal joint and a double outer portion, composed of two tapering horns (Plate XI, Fig. 8). In some of the larger spines one of these horns is much the greater of the two, and seems to be a direct, spur-like continuation of the base, while the shorter fork is articulated to the proximal joint. In the smaller spines the inequality of the two forks is much less; the long fork is most developed on the spines of the dorsal side of the maxilla. There is difficulty in making out these characteristics in all the spines, as they often lie on the slide in positions unfavorable to microscopic examination, and there remain many points undecided. The largest spines are found a little way from the tip; on the very tip of the trunk they are a little smaller, and towards the base of the proboscis they gradually grow smaller and smaller, and lie further apart; they are not found on the basal half of the organ. Upon that edge of the maxillæ which is dorsal when they are extended, are hairs such as are represented in Plate XI, Fig. 7. These hairs are for the most part inclined away from the tip-like barbs. Whether they are stiff, so that they serve to lacerate the flowers attacked by the moths, we were unable to determine; that this function is performed by the large spines is, we think, improbable, although Professor Comstock has suggested this view.

INTERNAL ANATOMY OF THE IMAGO.

The digestive canal of Aletia closely resembles that of the Milkweed Butterfly, *Danais archippus*, as described by Burgess. We shall therefore follow his account.

The canal traversing the proboscis opens into a large muscular pharynx, which occupies much of the lower part of the head, Plate VII, Fig. 2. The pharynx is oval, and is suspended by at least two pairs of muscles, one dorsal, m^1, and one frontal, m^2. At the anterior border of the pharynx is a triangular muscular flap, the epipharynx, m^3, overlying the opening of the proboscis, and serving as a valve to close the latter. The pharynx shows two layers of muscles, an outer, thicker one of longitudinal fibers, and an inner of transverse fibers. The pharyngeal cavity extends obliquely upwards from front to back, and is much broader than high.

"The pharynx, as is evident from its structure, serves as a pumping

* F. Darwin, Quart. Journ. Micros. Sci., XV, 385. Breitenbach. Arch. für mikros. Anat., XV, 8, and XVI, 308. Jena, Zeitschr. f. Nat.-Wiss.

organ to suck the liquid food of the animal through the proboscis, and force it backwards into the digestive canal, the process being as follows: The proboscis is unrolled, and inserted into the nectary of a flower; at this moment the muscles which suspend the pharynx contract, and its cavity is thus extended, creating a vacuum, which must be supplied by a flow of honey through the proboscis, into the pharynx. When the latter is full its muscles contract, the valve closes the aperture to the proboscis, and the honey is forced backward into the œsophagus. The pharynx is then again opened, and the same process is repeated. To prevent the food being sucked back from the œsophagus, it is probable that some of the numerous fibers in the muscular sac near the origin of the former can, by contraction, close its opening; but in any case, as the proboscis presents a free tube, and the œsophagus leads into the closed alimentary canal, it is evident that the former offers the easiest route for a supply to fill the vacuum produced in the pharynx." (Burgess.)

The organ just described escaped the notice of entomotomists until discovered by Burgess, and its functions were conjecturally ascribed to other parts. "The so-called 'sucking stomach' thus received its name from earlier writers, and when its structure was better known and such a purpose negatived, the capillarity of the fine tube of the proboscis, and even a peristaltic action of the latter, have been suggested to explain the power possessed by the butterfly to suck up its food."

At the upper extremity of the pharynx opens the narrow œsophagus, *oe*, and at the lower edge of the hypopharynx the common duct of the salivary glands, *sal*, discharges into the expanded base of the proboscidean canal. These glands consist of two long convoluted tubes, extending along each side of the thoracic central nervous system. In the general figure, Plate VIII, Fig. 2, the glands have been removed, in order to show the course of the œsophagus and ganglionic chain.

The œsophagus, Plate VIII, Fig. 2, *oe*, is a slender and delicate tube leading from the pharynx above, and after piercing the nerve commissure between the brain and the succeeding ganglion, passes straight through the thorax into the abdomen, in the very base of which it separates into two short branches, the upper leading into the food reservoir, the other the true stomach.

The *food* reservoir, *fr*, (or so-called sucking stomach), is a large membranous sac filling the anterior end of the abdomen; its walls are a very delicate cuticle, which is interiorly thrown into very curious labyrinthine wrinkles; near the neck is a region armed with singular processes or spines, scale-like in shape, each scale being armed with some six or eight very sharp teeth. The neck has an investment of transverse, annular muscular fibers.

In alcoholic specimens the food reservoir is much crumpled, and in all specimens opened was empty. There are some indications that the sac is not a simple one, but has secondary lobes or partitions; but this

point is still unsolved. Since the organ is not for sucking, as long supposed, and is evidently not digestive, it seems likely, or at least possible, that it serves simply as a reservoir. It is first developed in the pupal stage.

In a lateral view, as in Fig. 2, the neck of the reservoir is concealed by the anterior end of the stomach, which projects into two short lobes on each side of the neck.

The stomach, *st*, is very much smaller than in the larva, for it barely extends through four abdominal segments. Its walls have the same two muscular coats as we have described in the larval stomach, *vide supra*, and the epithelial lining is thrown up into beautiful glandular corrugations. The stomach is overlaid with the convoluted malpighian vessels, *mv*, six in number, three of which, on each side, unite and open by a short, common duct into the posterior end of the stomach. At the end of the stomach begins the peculiarly coiled small intestine, *i*, which passes to the left of the bursa copulatrix in the female, and of the genitalia in the male. The intestine passes into the wide terminal division, or rectum, *R*, from the front end of which runs out a curved blind pouch or cæcum, *c*. In Danais the terminal division is clearly separated into an anterior part or colon, and a posterior part, or true rectum, but the rectal region is less noticeable in Aletia.

The course of the aorta, or anterior extension of the heart, in lepidoptera, was not correctly described by the older authors. Burgess observed its strange bend in the butterflies, and has since studied it in several forms of lepidoptera, and published his results in a short paper.* In this article he describes and figures the course of the thoracic aorta in a noctuid. In Aletia it enters from the abdomen behind, bends immediately upwards, widens rapidly, makes a slight crook, and then, reaching the dorsal wall of the metathorax, to which it is secured by fibrous tissue, it makes a sharp bend and runs back upon its own course; next curves forwards, and, growing gradually narrower, runs along just above the œsophagus into the head, passing with the former through the brain.

The nervous system consists of a chain of ganglia and the nerves. The supra-œsophageal ganglion, or brain, occupies nearly the center of the head (Plate VII, Fig. 2, *Br.*), and is connected by very thick commissures with the sub-œsophageal ganglion, which passes gradually into the cord that leads to the first thoracic ganglion. This is quite distinct, but the second and third are almost completely fused, and connect with the abdominal ganglia by a very long commissure. In the abdomen (Plate VIII, Fig. 2) there are four nerve centers (*a. g.*, *a. g.*), as is almost always the case in the Lepidoptera, lying in the third, fourth, fifth, and sixth segments respectively. The last is the largest, and is compounded of two or more ganglia fused together; the principal nerves arising from it seem to innervate the organs of reproduction.

*Burgess. E. Proceedings Bost. Soc. Nat. Hist., XXI, 153–156.

TERMINAL BODY SEGMENTS AND ORGANS OF REPRODUCTION.

In the state of rest the eighth and ninth segments in the abdomen of both sexes lie concealed within the seventh, the intersegmental membranes in these cases being long enough to admit of this telescoping action. The eighth segment of the male does not differ from the preceding, except in wanting the spiracles and in its smaller size. It has, however, on its under side a thick shock of long hairs or scales parted down the middle, which, when this segment is retracted within the seventh, serves to form a soft cushion between the two, although this may not be its only purpose. The brushes of hair, to be described below, borne by the ninth segment act in the same manner as a cushion between the eighth and ninth segments.

The dorsum of the latter or terminal segment is produced backwards into a slightly curved hook, often compared with the telson of the crustacea (see Plate VIII, Fig. 2, and Plate X, Figs. 1 and 3, where the hook is marked with the figure 9). This hook covers the anal opening (*a.*), and in some Noctuids is greatly developed. Beneath it is a chitinous finger (Fig. 3, *f*) which is movable, but its function is obscure.

The ventral portion of the ninth segment forms a broad trough-shaped process (Plate X, *v. pr.*, Figs. 1–3), with upturned lateral edges, the penis lying in the bottom of the trough so formed, and hinged to each side of this segment are the "claspers," which are narrow triangular pieces with a slender, slightly incurved apex. Their exact shape will be more readily understood by referring to the lateral, dorsal, and ventral views given in Plate X, Figs. 1, 2, and 3, *c* left, *c'* right clasp.

There is still another and singular organ attached to the ninth segment. This is a sac with delicate membraneous walls thickly covered with slender, long-stalked scales (Plate IX, Fig. 3). The sac is very elastic, and may be protruded like a long finger and again retracted at will. The long hair-like scales give the organ the appearance of a brush. It is shown in various positions on Plate X, Figs. 1–3, *b*, the scales being removed in all the figures. This brush-sac is attached to the base of the claspers.

Morrison* first called attention to similar organs in *Leucarctia acræa*, and states they are protruded by being filled with fluid from within. He also noticed them in Danais, Agrotis, and Euplexia. Burgess (*loc. cit.*) described their structure in Danais, where, however, they are not placed in the same position as in Leucarctia and the Noctuids. The retractor muscle found in Danais we have not succeeded in finding in Aletia. Müller has also noticed these appendages, and regards them as scent organs. At all events it is probable they are organs for sexual excitation. They are not found in the female.[23]

The male organs of reproduction consist of a very large *testis*, two *vasa deferentia*, in each of which a tubular gland opens, a *ductus ejacu-*

* Morrison, H. K. Psyche, I, 21.

latorius, and the *penis*. The testis is shaped like a very thick, nearly spherical, button. (Plate VIII, Fig. 2, and X, Fig. 1, *Te.*) It is really a compound organ composed of two testes fused together. The testes can be found in the caterpillar as separate kidney shaped organs lying close under the dorsal vessel* in the fifth abdominal segment. In both larva and imago the fifth abdominal spiracle sends a branching tracheal tree which spreads over and into the testes on each side. The vasa deferentia lead from the posterior face of the testes. After a few convolutions they dilate into pod-shaped chambers, and then contract for a length of very fine tubes until reaching the point of union with the *glandulæ mucosæ*, into the basal portion of which the vasa deferentia seem to open. A short distance farther and the two vasa deferentia unite into a long, single duct, the *ductus ejaculatorius*, which is of larger diameter, contracting slightly near its end, again dilating into a very muscular, gourd-shaped section (Plate X, Fig. 1), which opens into the penis.

The latter organ is a slender, chitinous tube whose top projects between the claspers and below the anus, and which lies in the trough formed by the ventral arch of the ninth segment, as already described. It is protruded by a muscle on either side, the *protractor penis*, which is attached to the ninth segment. The end of one of these protractors is shown at *pp* in Figs. 1 and 2, of Plate X. The retractor was not found. From the tip of the penis project two prongs, which bear on their inner aspect several stout spines and some smaller teeth, as shown in Fig. 4, Plate X. These prongs seem capable of protrusion and retraction, and telescoped within the penis can be seen other chitinous processes and spines, apparently of considerable complexity, which could not be satisfactorily studied in the specimens at disposal.

FEMALE ORGANS OF REPRODUCTION.

The ovaries consist of four long slender tubes, lying in several folds on each side of the body. Their slender tips end in suspensory ligaments, all eight of which unite together immediately under the dorsal vessel. At their basal ends the ovarian tubes of each side unite into a uterine chamber (Plate IX, Fig. 4, *u.*), the short oviducts from which unite into a single oviduct, which passes through the eighth and ninth segment and opens between the lateral flaps of the latter beneath the anus.

Two accessory glands—colleterial or sebaceous glands, so called—which are concerned with secreting the egg-shell or the cement by which the moth fixes the eggs in place when laid, open into the common oviduct. The anterior gland is single; the posterior is a pair of glands with a single duct. Both consist of long cœcal tubes, with pear-shaped dilations near the base, followed by another roundish dilation. (See

*See Meyer. Zeitschr. wiss. Zool. I, 182. Also H. Landois, *ibid.*, xiii, 316.

Plate IX, Fig. 4, *a. gl.*[1] and *a. gl.*[2]) The paired glands lie close under the rectum, and would at first sight be supposed appendages of the latter instead of belonging to the oviduct.

At the base of the eighth segment, beneath, opens the vagina (*v.*), the orifice of which is therefore distinct from that of the oviduct. It is a long horny canal, which leads into a very large pyriform copulatory pouch. (Plate IX, Fig. 4, *c. p.*) This pouch is a very remarkable organ in the Lepidoptera. Its walls are very thick, and consist of a powerful muscular layer (Fig. 7, *m.*), within which is an epithelial layer (*sp.*) or matrix which gives rise to a stout *cuticula intima* (*cu.*). This last lies in heavy folds or ridges (Fig. 5), which have a general longitudinal direction, but with various curves and anastomosing branches. It is covered with little points, or teeth, which are stouter near the base of the pouch, and similar to the cuticular spines of the larval skin described at the beginning of the chapter. Each point arises in a little field of its own, separated by various-shaped boundaries from adjoining fields. (See Fig. 6.) These fields probably correspond to the underlying cells of the matrix. Near the base of the interior of the pouch a transverse triangular flap or valve is suspended from above, very thickly covered with short teeth, like those over the rest of the pouch.

There is a deep longitudinal furrow on the top of the pouch, so that cross-sections of the latter give a Y-shaped cavity. The vagina itself has a smooth, stout cuticula. Near the base of the vagina a slender sperm-duct (*s. d.*) leads from the vagina into the oviduct, through which duct the spermatozoa pass from the copulatory pouch, where they are discharged into the oviduct where the eggs are to be fecundated. The sperm-duct does not expand into a spermatheca, as is often the case.

In the female, as in the male, the two terminal segments are retracted, resting within the seventh, and do not bear spiracles. The eighth segment is like the preceding in shape, but smaller, with the pocket beneath for the vaginal opening, as described. From the anterior margin, each side, a stout spur projects into the interior of the abdomen (Plate IX, Fig. 4) for the attachment of muscles to move the segment.

The dorsum of the ninth segment forms merely a membranous covering over the rectum and contains no ossified element. The sides of the segment are produced into two lobes (see Plate IX, Fig. 4), which flank the oviduct and form a short ovipositor. Anteriorly the lobes send out two spurs like those of the preceding segment, but they are not shown in the figure. Ventrally the segment terminates in a short triangular piece projecting between the lateral lobes.

EXPLANATION TO PLATES.

PLATE VI.

FIG. 1. Longitudinal section of larva: *M*, mouth; *a*, *b*, *c*, legs; *St*, stomach; *sal*, salivary gland; *d. v.*, dorsal vessel; *m. v.*, Malpighian vessels; *In*, intestine; *R*, rectum; 1, 2, 3, 4, 5, false legs; *br*, brain; *g*, *g*, ganglia.

FIG. 2. Second proleg.

FIG. 3. Hook of proleg.

FIG. 4. Third right leg.

FIG. 5. Terminal hook or claw of same leg.

FIG. 7. Wall of the stomach, the epithelium removed: *tr*, trachea; *l*, *l*, longitudinal muscles.

FIG. 8. Cuticula from a dark band of larva.

PLATE VII.

FIG. 1. Longitudinal section of head of larva: *M*, mouth; *f*, frontal ganglion; *br*, brain; *s*, subœsophageal ganglion; *G*, *l*, first abdominal ganglion; *œ*, œsophagus; *Sp*, salivary tubercle or spinneret.

FIG. 2. Longitudinal section of head of imago. m^1, m^2, m^3, muscles; *mx*. maxillæ; *sal*. salivary duct; *P*, palpus; *œ*, œsophagus: *Br*, brain.

PLATE VIII.

FIG. 1. Exoskeleton, female imago: *a*, antenna; *cl*, clypeus; *E*, eye; *P*, palpus; *mx*, maxilla; *sp*, first spiracle; *eps*, episternum; *s?* scutum of prothorax; *s*, scutum: *sm*, scutellum; *w*, wing; *st*, sternum; *cx*, coxæ; *epm*, epimera; I, II, III, thoracic segments; 1–9, abdominal segments.

FIG. 2. General anatomy of male imago: *br*, brain; *œ*, œsophagus; *ao*, aorta; *g*, *g'*, *g''*, ganglia; *fr*, food reservoir; *Te*, testis; *St*, stomach; *m.v.*, Malpighian vessels: *i*, intestine; *c*, cæcum; *R*, rectum; *p*, penis; *a*, clasper; 1–9, abdominal segments; I–III, thoracic segments.

PLATE IX.

FIG. 1. Exoskeleton, ventral view: *p*, palpus; *mx*, maxillæ; *E*, eye; *s*, scutum (*l*) of prothorax; *l*, joint of first leg; *st*, sternum; *eps*, episternum; *pt*, patagium; *a*, *a*, median pieces.

FIG. 1, A. Section of scale.

FIG. 2. Three tarsal joints, leg of imago.

FIG. 3. Long scale from the abdominal brush of the male. ($\frac{1}{8}$-inch objective.)

FIG. 4. Female organs of reproduction: *c. p.*, copulatory pouch; *v*, *v*, vagina; *s. d.*, sperm-duct; *ov*, base of the four left ovarian tubes, and *u*, the uterine chamber or expansion of the oviduct; the right oviduct can be seen cut off; *c. v.*, copulatory vestibule; *a. gl.*^{1}, the single and *a. gl.*^{2}, the double accessory gland, only a portion of the tubes being shown; 8, the eighth abdominal segment, the upper part being indicated by dotted lines so as to show the oviduct beneath; 9, terminal segment with its lateral lobe.

FIG. 5. Cuticle from copulatory pouch.

FIG. 6. Small portion of same more magnified. ($\frac{1}{8}$-inch objective.)

FIG. 7. Transverse section through one of the folds of the copulatory pouch ($\frac{1}{12}$-inch objective): *m*, muscular layer; *ep*, epithelium; *cu*, cuticula intima.

PLATE X.

FIG. 1. Reproductive organs of the male, from above: *te*, testis; *v. d.*, vasa deferentia; *g. m.*, glandulæ mucosæ; *d. e.*, ductus ejaculatorius; *p*, penis; *v. pr.*, ventral process of ninth segment; 9, telson of same; *c*, left, *c*^{1}, right clasp; *b*, brush; *a*, anus; *p. p.*, protractor penis.

FIG. 2. View from beneath of the ninth segment of the male with its appendages. Letters as before.

FIG. 3. Lateral view of same: *f*, movable finger over the anus; other letters as before. The position of the brush is shown by dots, so as to make the shape of the clasp more evident.

FIG. 4. Tip of penis, from above.

PLATE XI.

FIG. 1. View of spiracle, abdomen of imago.

FIG. 2. Single spine of same spiracle.

FIG. 3. Exoskeleton of third thoracic and first abdominal segment: S^3, scutum; *A*, flap; *B*, tympanum; *Epm*, epimeron; *ex*, coxa; *Sp*, spiracle.

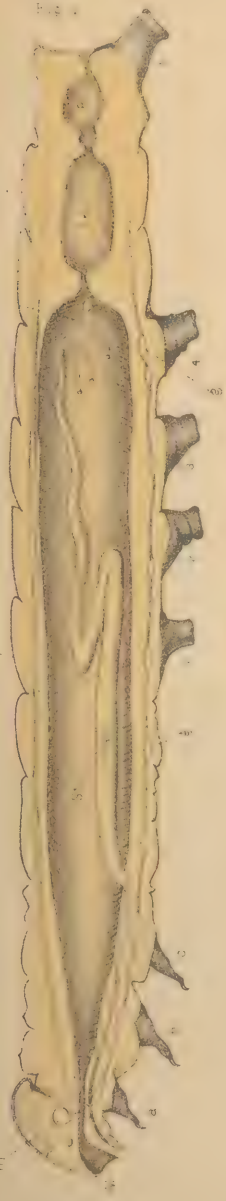
FIG. 4. Cuticula of first abdominal segment.

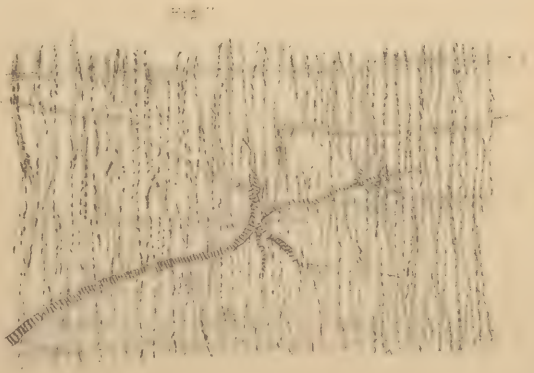
FIG. 5. Pores to which scales are attached.

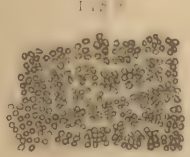
FIG. 6. Tip of maxilla.

FIG. 7. Hairs from maxilla.

FIG. 8. Single spine from maxilla.







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ANATOMY OF ALETIA

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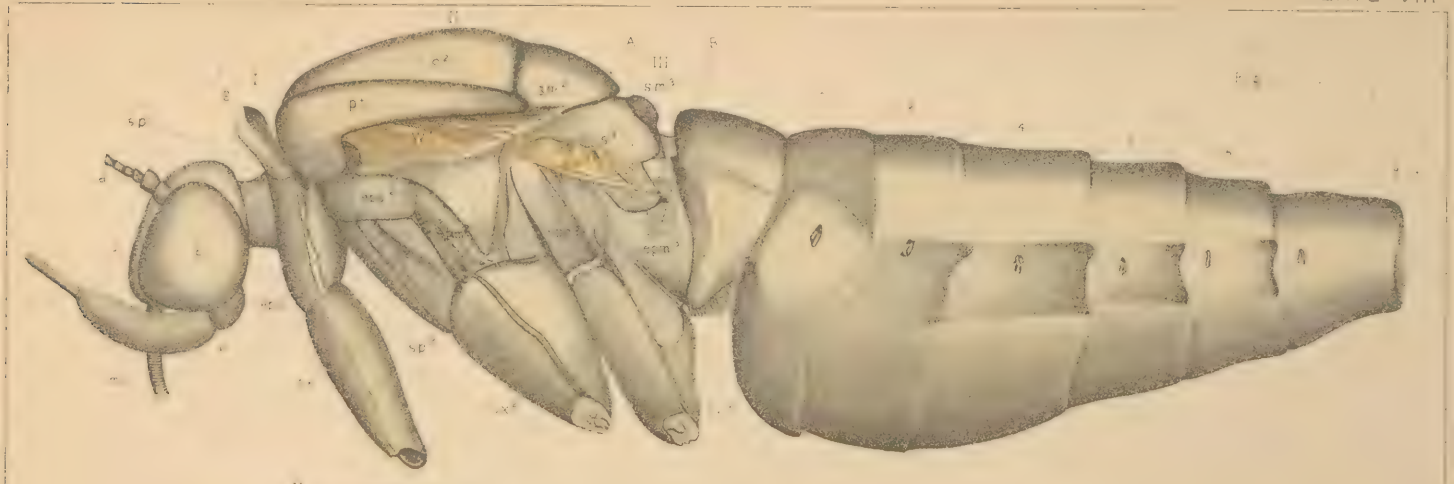
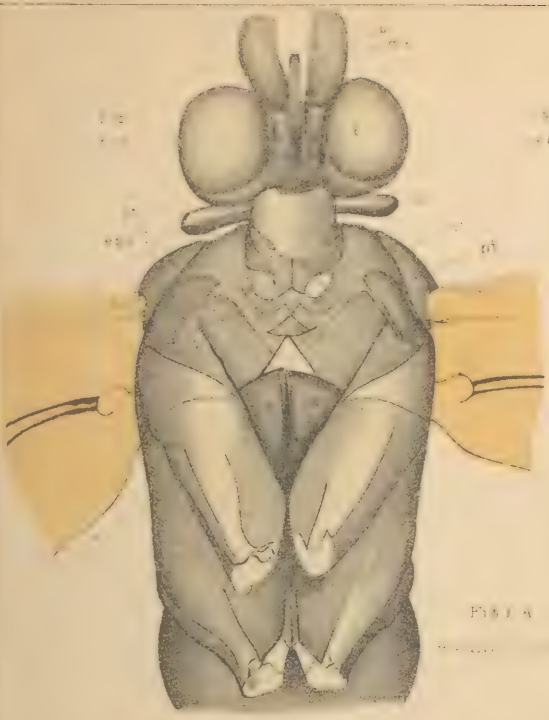
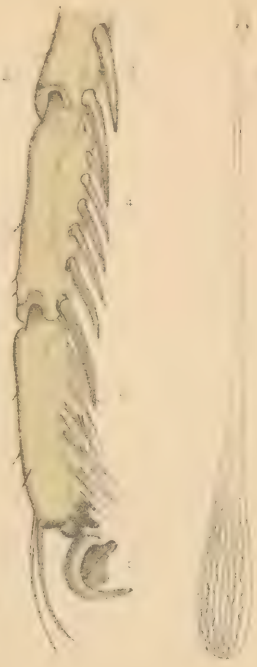


Fig 2. 3 x 10





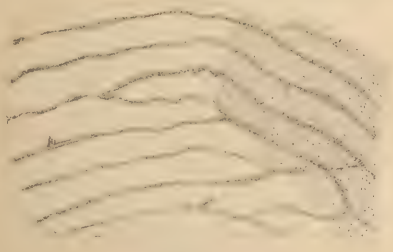
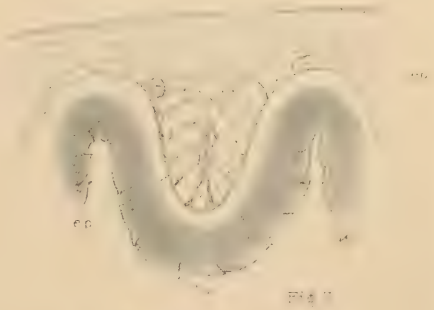


Fig. 5. x 50



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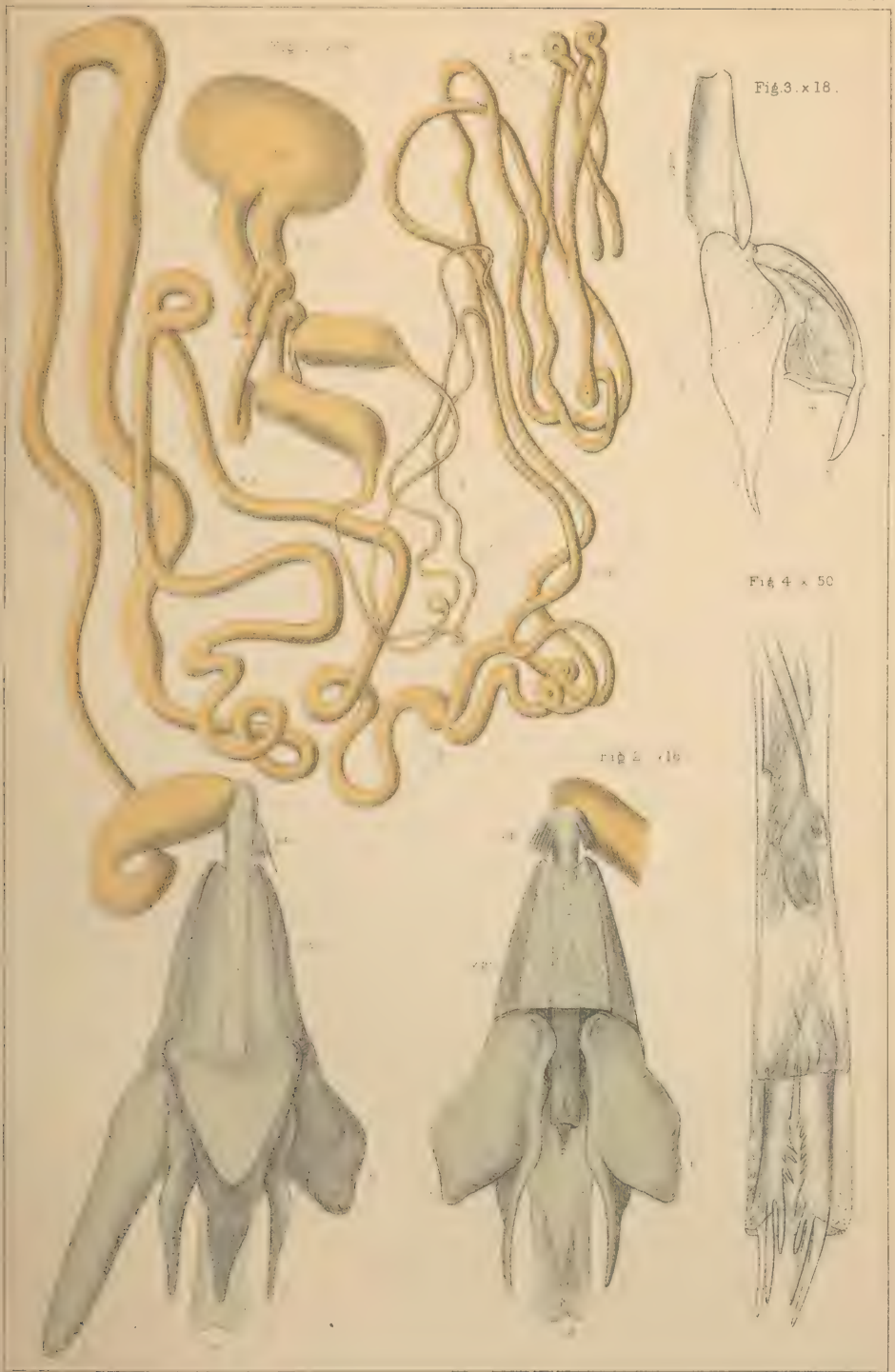

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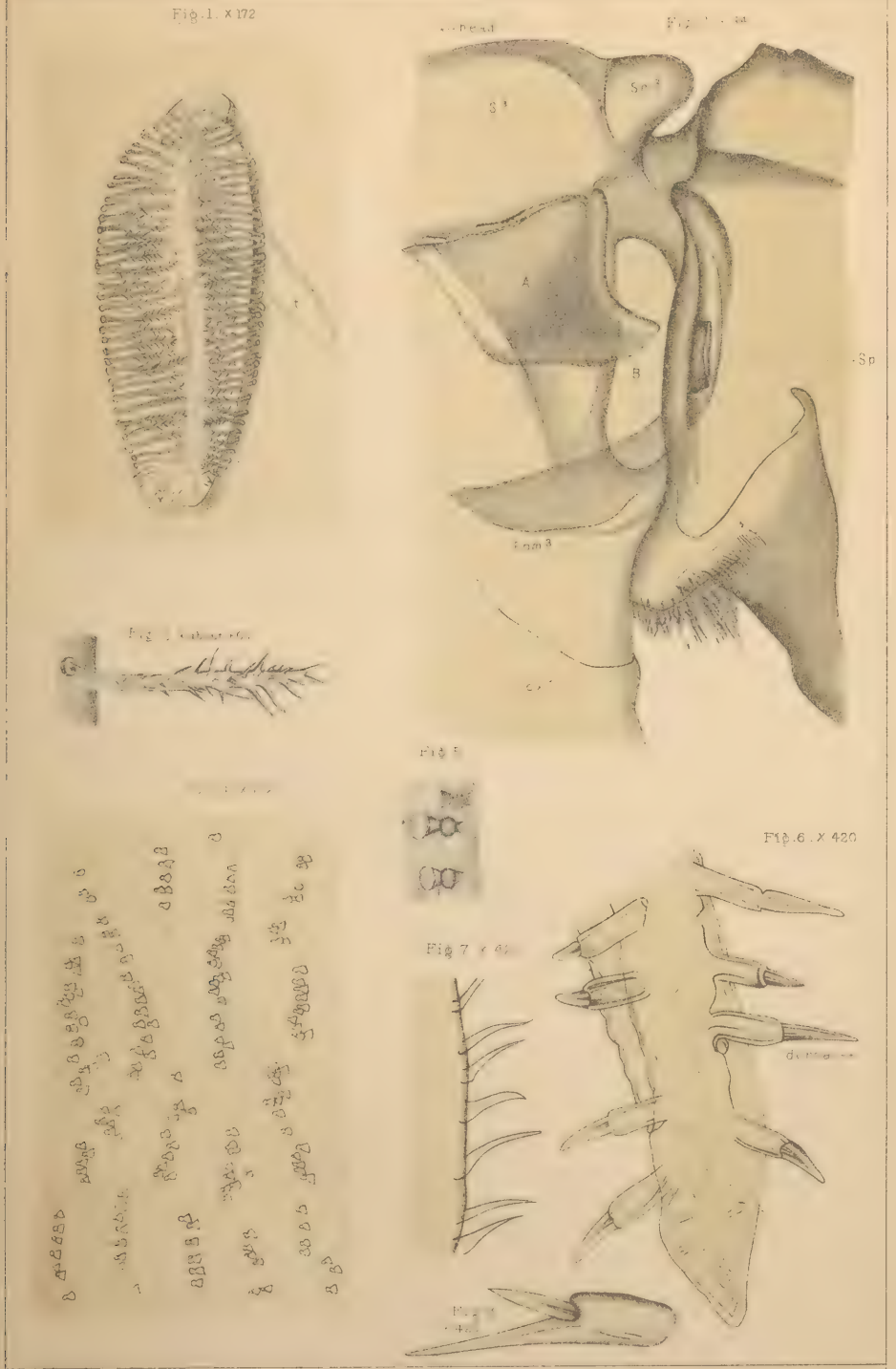

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